SUPPORT FACTOR OF OFFICE WORK CHAIRS

Zoran Vlaović[1], Danijela Domljan[2], Andrej Bublić[3], Ivica Grbac[4]
University of Zagreb, Faculty of Forestry, CROATIA,
[1]vlaovic@sumfak.hr; [2]domljan@sumfak.hr; [3]bublic@sumfak.hr; [4]ivica.grbac@zg.t-com.hr

Abstract: *The solution of the working chair as a real object of the human working environment is important from the viewpoint of construction of the seat, but also of the back, since these are the elements which are in a direct and close connection to the human body. The support factor (or comfort index) as one of the factors of sitting comfort results from the mechanical characteristics of the observed chair. This work shows the results of ''mechanical comfort'' which chair can offer to the user. The results of determining the seat comfort of sitting on office chairs are shown through the index of comfort (support factor) of chairs obtained from elastic characteristics of materials in the seat and chair, according to technical specifications HRS ENV 14443. The sitting position is the most frequent working position of the modern man industrial developed world. Independently of the type of the work, proper and physiologically correct sitting posture diminishes the fatigue during work and the strain of the spine, and the suitable sitting position significantly contributes to the increase of concentration and work efficiency.*

Keywords: *office work chair, sitting, comfort sitting, support factor.*

1. INTRODUCTION

The sitting position is the most common working position of the man and it is more and more present in the recent modern time. While this position is correct, then it diminishes fatigue during work, and also the spine strain which can, in comparison to the standing position, in case of irregular sitting position be much larger, and in this way it contributes the increase of concentration and efficiency, independently of the type of work. Besides, the sitting position is especially significant for the relaxation of the body and for rest, except of course, total passive relaxation in the lying position [1, 2].
The problem of the relation man – furniture from the ergonomic viewpoint is critical at most precisely in the question of correct sitting. The solution for the form of the office chair as the real object of the human working environment is important also considering the fact that the seat and the back are in a direct and close connection with the human body. These are the basic reasons why in design special attention is given to the problem of sitting. Except anthropometry and the working position, and ergonomic coordination of the office furniture for sitting and of the user, environmental factors which determine the function and the purpose of the chair are also important [3, 4].
Not just the seat and back, i.e. chair, characteristics are important for comfortable sitting, but also other factors like the acquired impression, load relief and the general satisfaction of the organism and its relaxation, but also fatigue, biomechanics, strain and circulation. Because of the metabolism, warmth and moist are for example constantly emitted and the feeling of comfort depends on the balance of receiving and emitting of warmth and

moist on the place where the body and the surface touch [5,6]. Just like Zarcharkow (1988) showed that the resistance towards changes is strongly connected to the size of the area of contact and the contact pressure [quoted in 5]. Therefore is the feeling of comfortability connected to the parameters such as pressure, temperature and relative moist on the area of contact of the body and the surface. The mechanical comfort is defined as a part of the whole comfortability which depends on the distribution of the contact pressure over the human during contact of the body with the seat. The contact pressure, distribution of pressure and the operational time are the main factors of mechanical comfort.

2. MATERIAL AND METHODS

Load/deflection diagram was based on the European prestandard ENV 14443:2004 – *Domestic furniture – Seating – Test methods for the determination of durability of upholstery* which specifies the research methods for determining the durability of upholstery and seats, and one of its parts refers to examining and determining the elasticity of the seats of office and other chairs. Figure 1 shows the device in the Laboratory for furniture testing on the Faculty of Forestry in Zagreb, with which measurements of the elastic characteristics of the seat were made.

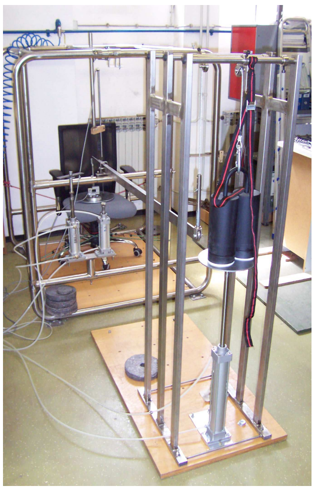

Figure 1. The device for measuring the elastic characteristics of the chairs

2.1. Chair samples

The samples included in the research were the office chairs with a five-legged base and wheels for hard or soft surfaces, pneumatic cylinders and high-quality mechanisms for position and comfort adjustment and with armrest. The seats were upholstered with decorative 100% polyester fabrics. There were relevant differences of the seat in the type of the upholstery filling: PU foam, combination of PU foam and springs or net. The chair samples had the symbols as follows: ST2, OA2, PT1 and MA2, whereas the first letter stands for the type of material (in seat), and the second letter and number represents

sample model (S – polyurethane foam, O – pocketed micro-springs with polyurethane cold-casted foam, P – polyurethane cold-casted foam and M – net).
The polyurethane foams had the following qualities: a) polyurethane foams with the density of 32 kg/m^3 (ST2) and b) cold-casted polyurethane foams with the density of 55 kg/m^3 (PT1). The seat of the model OA2 was made of springs with the diameter of 45 mm (wire diameter of 1,60 mm) and height of 40 mm and layer of polyurethane cold-casted foam (15 mm thick) with the density of 40 kg/m^3. Net stretched in the frame construction of the seat had the manufacturer's name *Pellicle*™ (MA2).

2.2. Research method

Elasticity is obtained by putting into relation the force with which we affect the surface of the seat and the deformations caused by the impact of this force (indentation force deflection test, IFD). The measurement system is consists of the circural aluminum seat loading pad (diameter 300 mm and the rounding diameter 800 mm) and of measurement devices (load-cell and inductive depth meter) which measure the force and deformation considering a referent point (Figure 2).

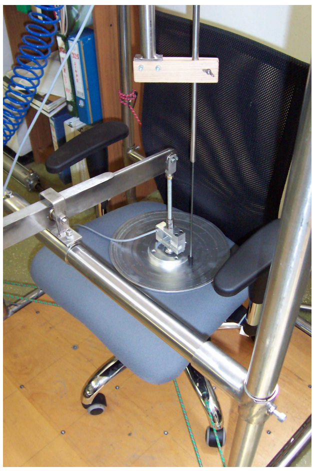

Figure 2. The position of the chair sample, seat loading pad with load-cell and inductive depth meter

The seat loading pad has been pressed with a force from 0 to 1000 N, with the speed of 90±5 mm/min, by means of a weight with a mass of 27 kg and of the system with a lever in the proportion 1:4,75. The weight and the lever are connected by a steel cable, and the system is aided through the pneumatic cylinder for easier handling. The whole system is connected with the computer through the amplifier *Spider8* (HBM GmbH, Germany). By means of the software *Catman 4.0,* values of force and shifts have been measured and later on processed with the program *MS Excel*. The management of the pneumatic cylinder and of the operational time has been made □lectros. The cycle of measuring the chair elasticity itself is specified and described in the above mentioned norm. After the data processing, as a result, the load/deflection curves shown further on in the text were obtained.

3. RESULTS AND DISCUSSION

The comfort index or support factor is the degree of furniture comfort against the user of that furniture, because the user wants to have softness during high and low load, which is very interesting when applying the same material to seats and backrest, especially in armchairs and sofas [7]. Higher support factor values have been equated with improved overall cushion comfort.

The support factor is the ratio of 65% IFD to 25% IFD. This number gives an indication of cushioning quality and higher numbers are desired [8]. The values in the following table were obtained from the figures of the load/deflection curves (Figures 3 to 6).

Table 1: Support factor or comfort index of chair

Chair model	Deformation at 1000 N (100%)	Deformation at 65%	Force at 65% of deformation (a)	Deformation at 25%	Force at 65% of deformation (b)	Support factor a/b
ST2	37,47 mm	24,36 mm	550,62 N	9,37 mm	306,30 N	1,8
OA2	31,75 mm	20,64 mm	645,54 N	7,94 mm	262,02 N	2,5
PT1	41,19 mm	26,77 mm	496,56 N	10,30 mm	233,60 N	2,1
MA2	47,88 mm	31,12 mm	369,18 N	11,97 mm	51,70 N	7,1

The next diagrams show the force with which the chair has been loaded and the maximum deformation caused by this force, which is different from chair to chair because of different materials built in the seat. Along with these two basic figures on each graph, four points have been marked: two at the force of 400 N on the loading and unloading curve and two at the force of 600 N. These points show the lagging of the materials during unloading. Since the seat mostly influences the appearance of the elasticity curve in the entire system, we can say with certain reserve, that the obtained curve is the seat elasticity curve.

The curves of polyurethane foams are significantly different in comparison to the curve of net. The PU foam (Figure 3) of the model ST2 is somewhat rigid, then it loosens and enables the sinkage of the body at forces from 250 N to 600 N, and then it becomes rigid again, probably because of the closeness of the rigid basis and high compression.

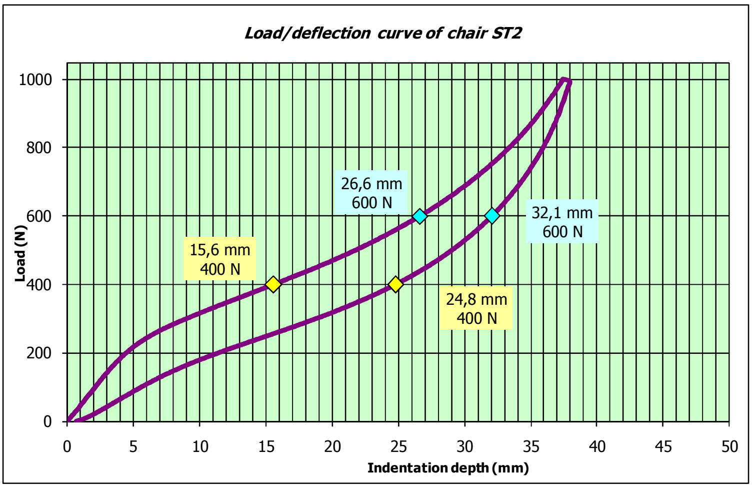

Figure 3: Load/deflection curve of chair with PU foam (ST2) in seat

The diagram of the PU cold-casted foam and micro-springs OA2 is also linear which completely corresponds to the characteristics of the springs at such measurements (Figure 4). In this seat, the springs most probably takes the major load on themselves, and the layer of the PU foam takes only the initial load and gives a feeling of starting softness during sitting.

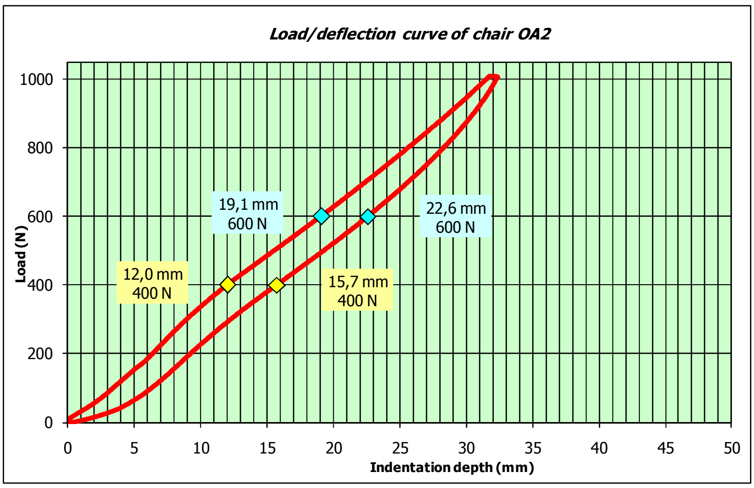

Figure 4: Load/deflection curve of chair with PU foam and springs (OA2) in seat

The elasticity curve of the cold-casted PU foam (PT1) are very similar with PU foam (ST2) in appearance. The PU foam of chair PT1 is in the beginning somewhat rigid (Figure 5), and then, up until the end of the load, it allows a good deflection.

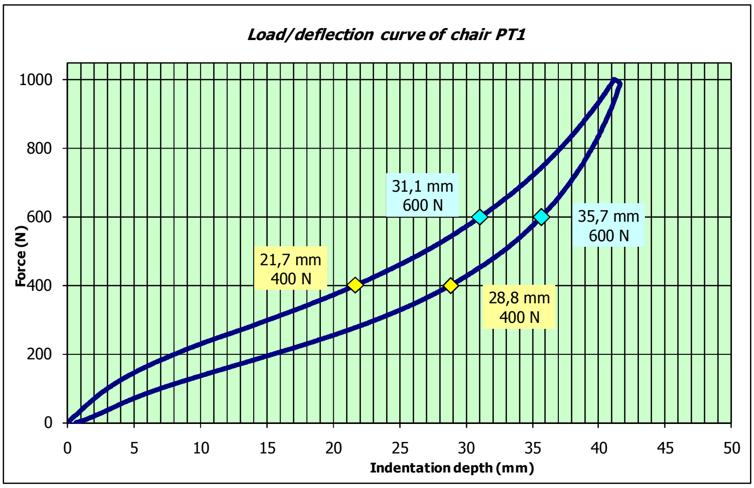

Figure 5. Load/deflection curve of chair with cold-casted PU foam (PT1) in seat

Figure 6 shows good characteristics of the net-like materials, which in start and for a long time afterwards have a large deflection for a relatively small force, and later on they behave almost linearly up to big forces enabling further on a large deflection.

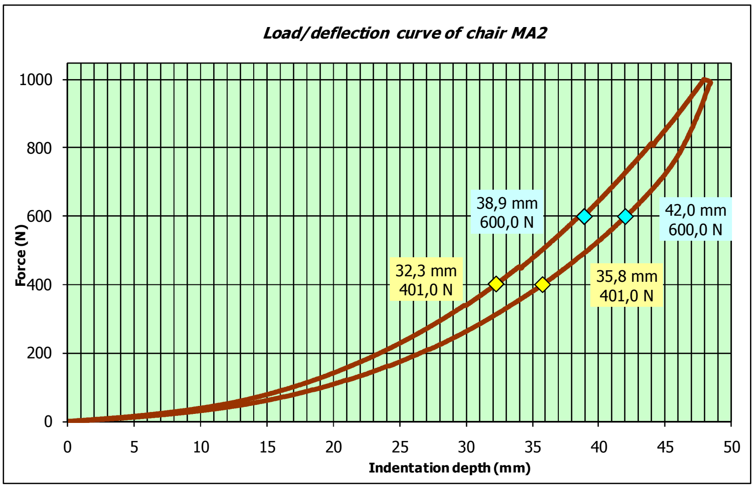

Figure 6. Load/deflection curve of chair with framed net (MA2) in seat

The shown load/deflection curves are the results of the □lectros of elastic characteristics of the chairs. The complete results of measurement and diagrams can be found in the original research [9].
Table 1 and Figure 7 show that the highest comfort indexes appears for the chairs MA2, i.e. framed net, which indicates their general comfortability and seat quality, but it certainly has to be repeated that they is not made of polyurethane material.

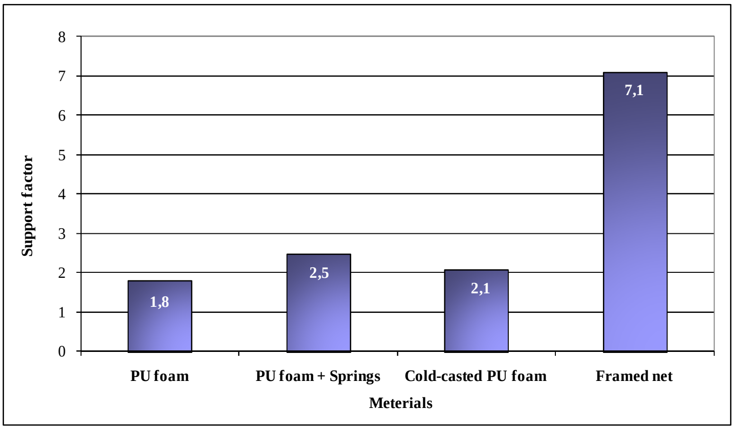

Figure 7: Comfort index for materials of seat upholstery

Chairs with polyurethane foams (of any kind) with a rigid base as opposed to the net-like constructions have the characteristic of the lagging of the material – hysteresis. Lagging is mostly noticed when the body moves and the foam does not manage to change its shape, so the body stays unsupported. It causes the sitting imbalance and thereby causes a sudden concentrated compression of that part on the side where the center of gravity is [10]. It is important to mention that all of these diagrams (Figures 3 to 6) and the sizes which come out of them relate to the action of chair (seat) load and that the time factor is not included in the observation. In the short term, during the first minutes of sitting on the chair and for a shorter times afterwards, the indexes of comfort are high, but afterwards the comfort probably decreases.
Because of the presence of the entities comfort and discomfort [11], situations displayed by the Figure 7 often occur, where a better comfort index for chairs with springs than for chairs with regular and cold-casted foams has been noted. The significance of these exceptions has not been examined, but a small difference is visible. Most important is the significant difference in evaluating the chairs with net, the values of which are higher for more than three times.

4. CONCLUSION

On the basis of the conducted researches and measurements of deformation of the office chairs, and determining the comfort index, the following conclusions can be made:

- There are major differences among the materials of seat upholstery and their constructions. Therefore is such a diversity of the assortment offer for the ultimate users reasonable.
- Since in the whole system the seat mostly influences the appearance of the elasticity curve, we can say with a certain dose of reserve, that the obtained curve represents the elasticity curve of the seat.
- Since the time factor has not been examined, in short term, in the first moments of sitting on the chair and for a shorter time afterwards, the comfort indexes are high, but they can drop.

- The greatest comfort index was provided by the seat with framed net. The influence of hard surface on sitting is primary, and thence it follows that the frame construction of the seat with net is most adjustable to those parts of the body on which people sit.
- Hysteresis appears in chairs with polyurethane foams and with rigid base unlike the net-like constructions, which causes imbalance of sitting and causes quick concentrated compression of that part of the body on the side where the center of gravity is.
- The span of the loading and unloading curves, .i.e. the material characteristics, which cause these differences has to be such that they are smaller, because then the relocation on the seat is easier and the support better.
- In the results of examination of mechanical characteristics of chairs with polyurethane foams, a better comfort index has been noticed for chairs which were in the subjective test evaluated as uncomfortable. The most probable reason for it is the existence of the comfort and discomfort entity.

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